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OVERLENGTH TRUCK COMBINATIONS

Alberta
TRANSPORTATION

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A TRAFFIC OPERATION AND PERFORMANCE EVALUATION OF OVERLENGTH TRUCK COMBINATIONS

Alberta Transportation
Transportation Safety Branch

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Supplementary Notes

Abstract

Turnpike Doubles (previously dis-allowed in Alberta) were tested for their impact on some typical rural highway and urban street situations. As a comparison, permitted overlength truck trailer combinations like the Rocky Mountain Doubles and the Triples were also evaluated. The critical vehicle and operational characteristics under scrutiny were speed, acceleration, passing, stability, and manoeuvrability. To measure offtracking, an off-road site was used to simulate an intersection, for the three overlength configurations to turn at various radii.

A literature research review was examined as it pertained to the foregoing and such areas like braking, dynamic stability and traffic collisions. Permit practices of other North American jurisdictions that allowed longer combinations were also included.

The resulting recommendations were that the Turnpike unit with a B-dolly should be allowed on divided highways. Operation on undivided highways should only be considered for the Rocky Mountain Double configuration, and be limited to highways with high standard geometrics.

Key Words	Distribution Statement
Overlength; Turnpike Double; Rocky Mountain Double; Triple; offtracking; dolly	Unrestricted

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Allan Lo. P. Eng.	Unclassified	Unclassified

Alberta
TRANSPORTATION

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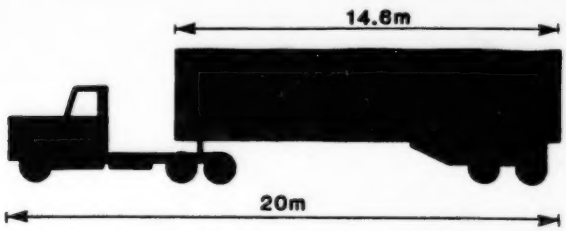
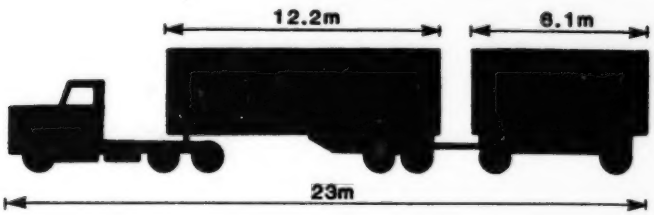
DIAGRAM 1

VARIOUS TRUCK COMBINATION CONFIGURATIONS

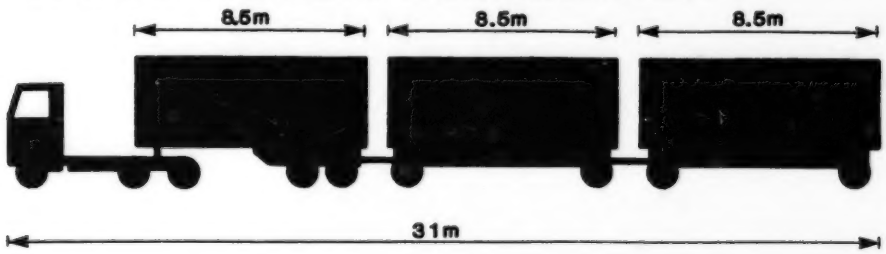
SEMI-TRAILER



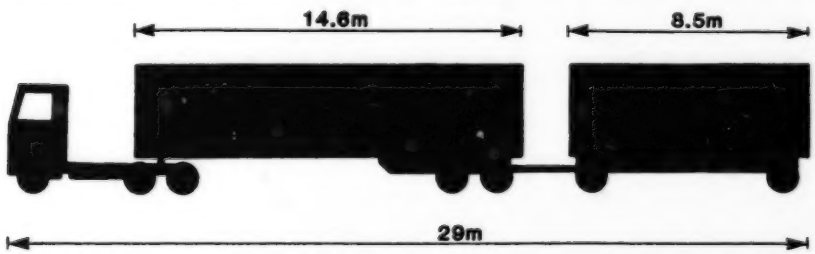
DOUBLE TRAILER COMBINATION



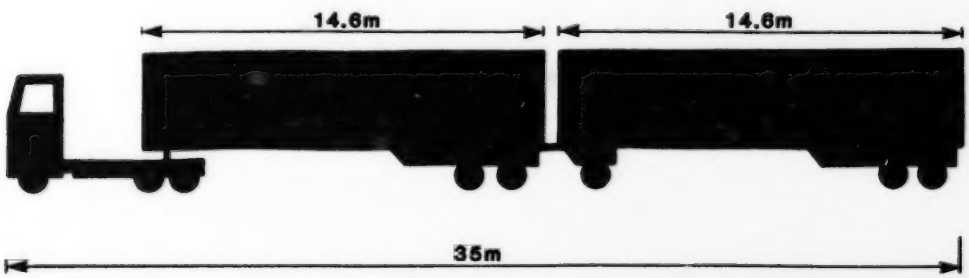
TRIPLE TRAILER COMBINATION



ROCKY MOUNTAIN DOUBLE



TURNPIKE DOUBLE



EXECUTIVE SUMMARY

Various provinces and states have been allowing the double 14.6 m (48 ft) truck and trailer combination, commonly known as the Turnpike Double, on their highways for some time. Now, Alberta is faced with the decision to permit or dis-allow this configuration in this province. Tests with MacDonalds Consolidated's Turnpikes on Highway No. 2 were initiated to help answer the question. The report addresses all the pertinent operational and safety characteristics of the Turnpikes and other overlength truck trains - Rocky Mountain Doubles, Triples - as well as discussing findings from other sources. In conjunction, a review is made of the practices and conditions that govern the operation of overlength truck combinations across North America.

The recommendations are:

1. The Turnpike Doubles should be allowed to operate on divided highways on the basis of permits. The maximum allowable trailer length should be 15.2 m (50 ft.), and the maximum overall length should be 35m (115 ft.).

2. An operating condition that should accompany the Turnpike Double permits is the requirement of a "B" dolly converter or a "B" train configuration.

3. The reverse configuration of the Rocky Mountain Double should be permitted to run as an overlength vehicle, as long as the lead trailer is heavier than the back trailer.

4. The weight differential rule should apply to all other overlength truck combinations, with a further stipulation that the back trailer of the Triple should be the lightest.

5. Operations of overlength truck trains on two-lane undivided highways should only be considered for double combinations upto 29m overall length, and only on designated highway routes with high standards of geometrics.

FOREWORD

Overlength truck combinations, as referred to in this report, are articulated vehicle units totalling more than 23 m length - the legal limit in Alberta. Currently, the three most prevalent configurations of overlength truck combinations are the Rocky Mountain Double (RMD), the Turnpike Double (TPD) and the Triple (TRI).

Depending on the purpose and nature of the operator's haul, any one of the three configurations can be advantageous over the others. The distinction between the units lies in the length and number of trailer connected. The Rocky Mountain Double has a 12.2-14.6m (40-48 ft) long semitrailer in front, pulling a second and shorter full trailer of 7.9-8.5 m (26-28 ft) length; the reverse configuration would consist of the two trailers switched around in position. These configurations have an increased cubic volume capacity of upto 35% over a regular double. Further expansion in capacity is achieved by coupling two long trailers as in a Turnpike Double. With up to two 14.6 m trailers coupled, the overall length can reach 35 m. The Triple, as the name suggests, is a three 7.9-8.5 m trailer combination.

The economic efficiency in operating long vehicle trains derives from the ability to carry more goods per trip. In some cases, the configurations also provide the flexibility to deadhaul empty trailers. Potentially, this adds up to reduction in total trips required and can lead to 20-25% fuel savings [20], plus savings in driver wages. Of course, with the gross vehicle weight restrictions, the configurations are most productive only when carrying low to medium density freight.

It is recognized that there are other truck trailer arrangements that are just as highly productive and still stay within the legal overall length limit. The difficulty for the carriers is the lack of compatible equipment. These vehicles were not tested and would not be evaluated in the report.

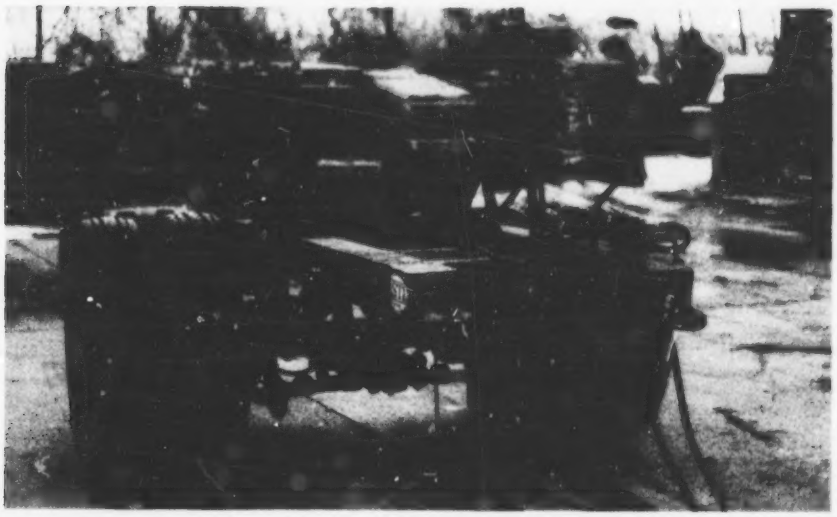
Another important part of the truck vocabulary is the coupling arrangement. The tractor typically has a fifth wheel device that sits on top of the driving axle; the connection is made when the fifth wheel latches onto the kingpin of the semtrailer. In articulated units consisting of more than one trailer, the two trailers are normally linked via a dolly converter. The converter has the same fifth wheel device for linkage with a following trailer's kingpin, and this itself is attached to the leading trailer by a hitch and hook set up.

The very first converter type is called the "A" dolly, with a V-shape drawbar that converges into a hitch point on the leading trailer. The truck combination that makes use of this type of dolly is referred to as a "A" train and is the only converter configuration available in the U.S. so far.

A second generation of converters is the so-called "B" dolly, which has gained acceptance in Alberta for some time now. There are two drawbars and two hitch points instead of the one, and as discussed later on, the attachment makes for a more stable truck train. An accompanying feature is the built-in capability of the dolly to self-steer.

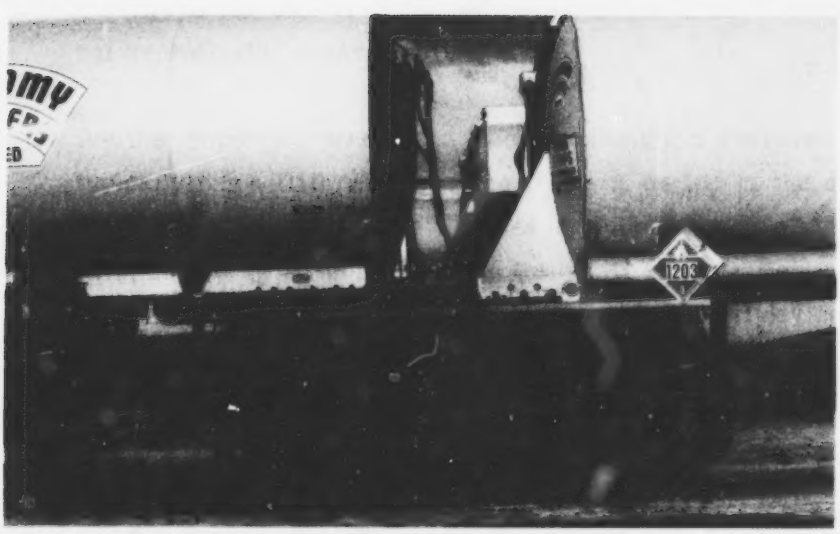
Finally, another hybrid coupling system that is a departure from the original converter concept is the "B" train. The dolly vehicle is eliminated, in its place, the fifth wheel assembly sits on the rear axle of the leading trailer. The assembly either slides out with the rear axle or is permanently fixed in this position (see Diagram 2). A "B" dolly that is locked to prevent steering would function the same way as the "B" train. Popular applications in Canada are in the area of bulk goods carriers like liquid tankers and grain hoppers.

"B" DOLLY/"B" TRAIN ARRANGEMENTS



"B" dolly Steerable

Dual pintle hitches on trailer



"B" train

PLATE 1

DIAGRAM 2 COUPLING ARRANGEMENT SYSTEMS

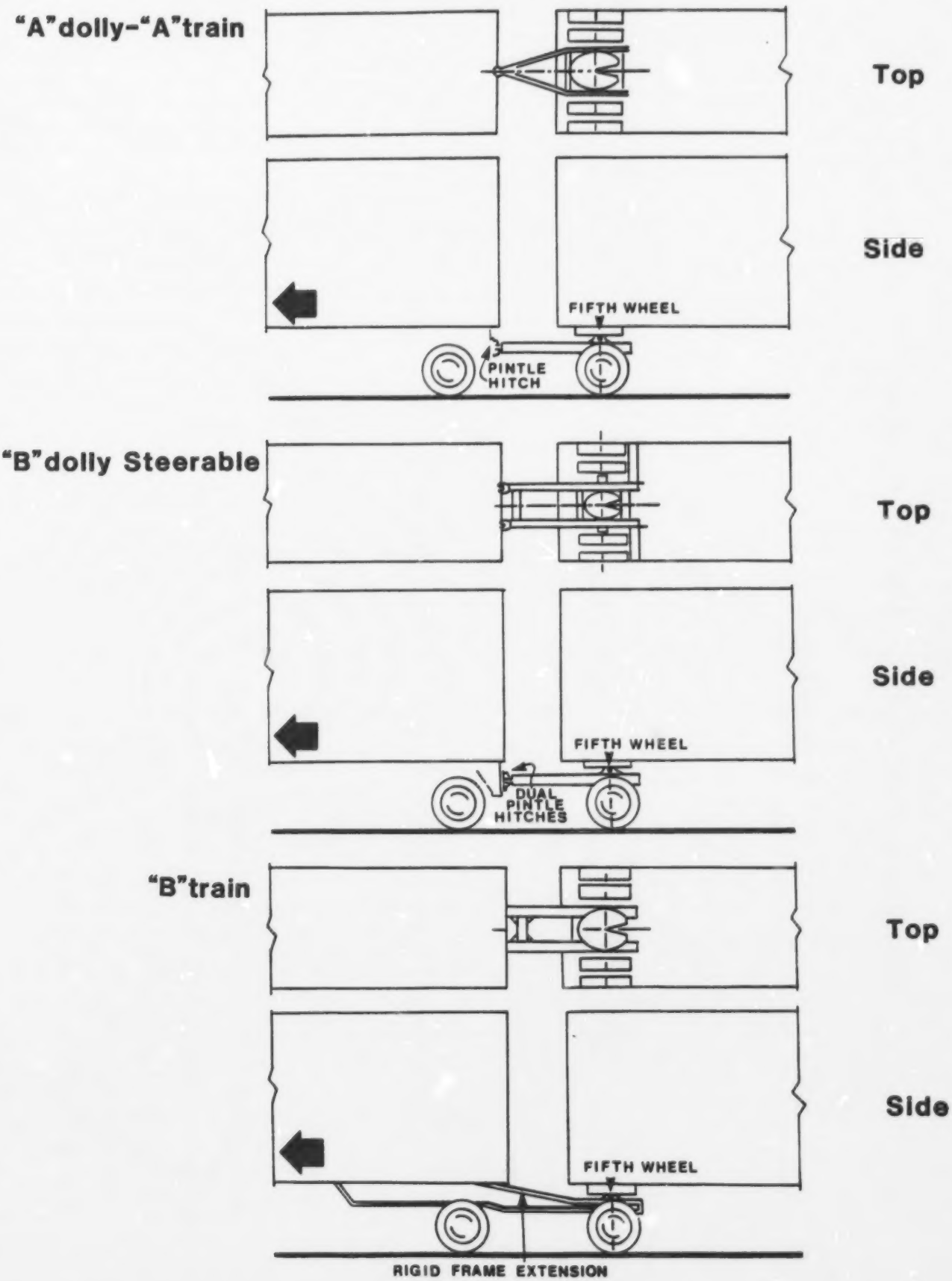
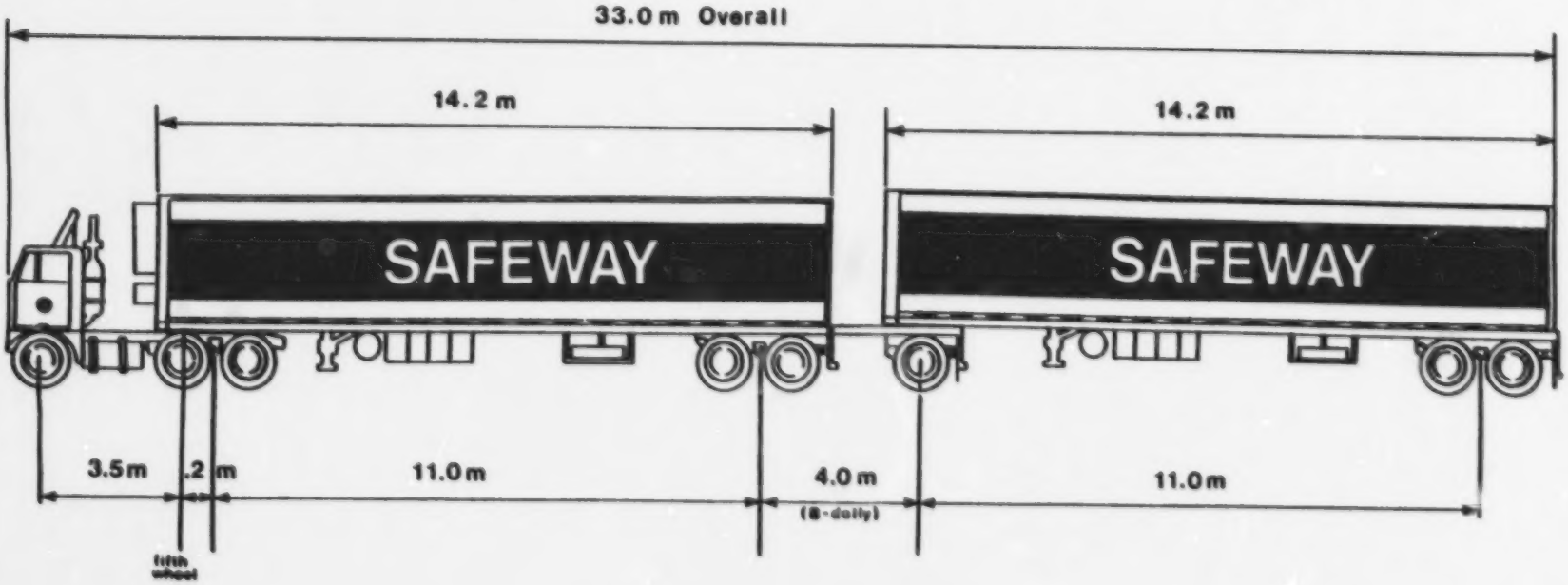


DIAGRAM 3 TYPICAL TURNPIKE UNIT TESTED



Average GVW (Gross Vehicle Weight): 45,300 kg

Engine: 350 or 400 Hp Cummins

ASTL 'B' dolly set at 170 - 240 kPa steering pressure

Tractor Axle Width 2.2 m

Trailer Axle Width 2.4 m

INTRODUCTION

In 1969, Canadian Freightways was given a special permit to operate triple trailer combinations on Highway No. 2, between Edmonton and Calgary. Alberta became one of the first road jurisdictions in North America to allow overlength vehicles of this kind. The Triples became part of the company's daily routine for nine months, during which time the vehicles were subjected to tests and observations. Then in the spring of 1970, the "Report on the Testing of Triple Trailer Combinations in Alberta" was published; the findings formed the basis to permit Triple operations for all carriers.

Later, another overlength vehicle was permitted on Alberta's divided highways - Rocky Mountain Doubles. Similar testing, however, was not carried out. Now, the trucking industry is lobbying for a truck trailer configuration that can be considerably longer than the Triples. At potentially 35 m, the Turnpike Double would become the longest road train configuration.

Considerable changes in the truck capabilities and coupling systems, in the car-truck size disparity, and in the traffic volume, have taken place since the Triple test. Renewed examination of all overlength vehicles, in particular the proposed Turnpike Double, was deemed appropriate. The testing began March 12, 1985 and ended July 12, 1985.

MacDonalds Consolidated was selected by the Alberta Trucking Association to operate the Turnpike Doubles for the trial period. Maximum of three round trips were made each weekday, with one of the trips stopping at Red Deer. The drivers all had over 20 years of truck driving experience and had been hauling Rocky Mountain Doubles prior. The details of a typical truck unit is shown in Diagram 3.

In addition, Canadian Freightways contributed a Triple for the off-road offtracking tests. Other overlength truck trains were randomly selected as-is on the highway for comparative observations (unbeknown to the drivers).

BACKGROUND

With the exception of the Turnpike Doubles, the concept of longer and more productive trucks finds it origins in the west. From Tables 1 and 2, the west is obviously well represented. Topographical variations, spread-out population centres, and the absence of a well-utilized railway network in certain regions, all contributed to the demand for a more productive and efficient trucking service [20]. It is not coincidental that Alberta resembles some western states (like Oregon, Colorado and Nebraska) in population density, in the road system and the traffic levels. On the other hand, states like Nevada and North Dakota, and provinces like Saskatchewan and Manitoba, all have lower density population centers and consequently, lower traffic volumes. At this point, British Columbia is the only western province that has resisted the emergence of overlength vehicles - the mountainous terrain and the lack of a highly developed divided highway link are key obstacles. The state of California is another exception; one of the reasons is the massive population concentration and the resultant traffic characteristics.

Quebec appears to break away from the pattern, as it is is the only eastern jurisdiction other than private toll road authorities in some eastern states, to allow overlength road trains. The volumes in the Montreal area approach those on the "super highways" of the states. Yet Quebec's neighboring Ontario has refused the long vehicle trains on the very grounds of degradation to the highway capacity and level of service, in addition to some operational and safety concerns [4].

The non-uniformity will likely continue in Canada because the regulations of the trucking industry will remain under each provincial government's jurisdiction. (The on-going CCMTA - RTAC study on truck weights and dimensions will hopefully serve to bridge the differences). In the states, the U.S. Department of Transportation has attempted to bring about some consistency on the interstate system, but the enshrouding controversy has not resolved the issue - some states still will not allow overlength truck combinations.

TABLE 1. CROSS-PROVINCE PRACTICE WITH OVERLENGTH TRUCK COMBINATIONS

PROVINCE	ALBERTA	SASKATCHEWAN	MANITOBA	QUEBEC	B.C.	ONTARIO
MAXIMUM GVW (kg)	53,500	53,500	56,500	62,500	63,500	63,500
MAXIMUM LENGTH (m)						
TPD	under testing	no maximum	-	no maximum lengths but trailer must be 14.65 m maximum	maximum length is 23 m	maximum length is 23 m
RMD	29	length	27			
TRI	31.25	restrictions	33.25			
PERMIT DURATION	one year	agreement under which a yearly permit is issued	one year	3 months	overlength trucks not permitted	
DRIVER REQUIREMENTS	"well experienced and of good driving record"	3 years driving semitrailer and 2 years driving combinations; air brake endorsement	"fully trained and well skilled"	5 years driving 11,000 kg + trucks		
TIME RESTRICTIONS	weekends and holidays not permitted	no restrictions	weekends and holidays not permitted	not allowed during winter; during peak hours in Montreal and Quebec City; not on Sundays		
SPEED RESTRICTIONS (km/h)	100	90	100	90		
DOLLY TYPE REQUIREMENTS	none	tested and approved "B" dolly type	none	Tandem dolly or "B" train configuration with three axles		
RURAL ROADWAYS PERMITTED (km)	400 km divided	500 km divided	180 km divided	over 700 km divided		
TRAFFIC VOLUMES	9,000-33,000 mainly in the 10,000 range (1984 AADT)	2,600-6,400 mainly in the 3,000 range (1984 AADT)	3,700-7,700 (1983 AADT)	15,000-35,000 6,000-12,000 (1982 AADT)		
NUMBER OF T?D CARRIERS	-	10	-	30 with 100 permits		

TABLE 2. CROSS-STATE PRACTICE WITH OVERLENGTH TRUCK COMBINATIONS

STATE	ALASKA	ARIZONA	COLORADO	IDAHO	MONTANA	NEBRASKA
MAXIMUM GVW (kg)	49,500	50,500	36,400	48,000	56,000	empty*
MAXIMUM LENGTHS(m)						
TPD	27.5**	32	32	32	29	32
RMD	27.5**	27.5	29	32	29	32
TRI	-	32	32	32	-	32
RURAL ROADWAYS PERMITTED (km)					entire highway system	
Four-lane	80	45	1,000	1,000 ***	2,700	
Two-lane	700 for RMD & TPD	-	-	3,500 for RMD & TRI	16,000 for RMD & TPD	not known
SINCE	1981	1976	1981	1968	1968	1984
COMMENTS	-	population density higher than Alberta	denser popoulation - more mountainous roads	-	-	population density comparable to Alberta

* Testing the combinations with empty trailers
** Combined trailer length
*** Based on WHI offtrack formula, other routes maybe open to TPD.

Source: From FHWA and WHI and contacts with various state officials as of July, 1985

TABLE 2. CROSS-STATE PRACTICE WITH OVERLENGTH TRUCK COMBINATIONS (CONTINUED)

STATE	NEVADA	NORTH DAKOTA	OREGON	SOUTH DAKOTA	UTAH	WYOMING
MAXIMUM GVW (kg)	58,600	48,000	48,000	58,600 TPD 47,700 RMD	58,600	36,400 on Interstate 53,200 on others
MAXIMUM LENGTHS(m)						
TPD	32	33.6	-	33.6	32	-
RMD	32	33.6	20.7 **	27.5	28 on two-lane 30 on four-lane	24.4 **
TRI	32	33.6	32	-	32	-
RURAL ROADWAYS PERMITTED (km)	entire highway system	entire highway system		entire highway system	entire highway system	
Four-lane	1,100	1,300	1,000	1,100	1,100	1,400
Two-lane	6,700 for all combinations	2,500 for all combin-ations	5,000 for RMD & TRI	11,400 for RMD only	12,000 for RMD only	8,800 for RMD only
SINCE	1968	1981	1967	1978	1969	1974
COMMENTS	-	-	denser population than Alberta	-	population density comparable to Alberta	-

* Testing the combinations with empty trailers
** Combined trailer length
*** Based on WHI offtrack formula, other routes maybe open to TPD.

Source: From FHWA and WHI and contacts with various state officials as of July, 1985

TABLE 3. TURNPIKE ROAD AUTHORITY PRACTICE WITH OVERLENGTH TRUCK COMBINATIONS

TOLL ROAD AUTHORITY	FLORIDA	INDIANA	KANSAS	MASSACHUSETTS	NEW YORK	OHIO
MAXIMUM GVW (kg)	62,700	57,900	54,500	57,900	65,000	57,900
MAXIMUM LENGTHS(m)						
TPD	33.6	no overall	36	33	34.8	33
RMD	-	length	36	33	34.8	33
TRI	-	restrictions	36	-	- -	
RURAL ROADWAYS PERMITTED (km)						
Four-lane	435	250	370	210	850	385
ACCESS TO/FROM (km)	2-5	25	30	not known	under 1 km	not known
SINCE	1966	1964	1960	1959	1959	1960

OPERATIONAL CHARACTERISTICS

Operating Speed

The legal speed limit on the four-lane divided Highway No. 2 are 110 km/h for cars and 100 km/h for trucks. But because of MacDonalds Consolidated's policy that the drivers must not exceed 97 km/h, the Turnpikes were run consistently at speeds of 95-97 km/h. (A Rockwell International trip computer was installed by the company for monitoring purposes.) Other overlength trucks were observed to travel in the 80-105 km/h range. The trucks could be operated at higher speeds, but large fleet carriers like MacDonalds opted for the lower speeds to save fuel and wear of equipment.

The overlength truck's deviation from the mainstream traffic speed was not observed to be a hinderance or safety hazard in the traffic stream interaction. Cars were able to manoeuvre around and pass the trucks with relatively little delay. The instances where disruption to traffic was created occurred on long and steep grades. The loaded Turnpikes were observed to drop to 40-50 km/h on the Antler hill, northbound (3.2-5.6% grade for 2000 m) and to 55-65 km/h on the Blindman hill, southbound (5% for 900 m). From radar studies on the other truck configurations at the two steep hill sites, the legal length truck combinations operated in ranges of 42-96 km/h, and 50-100 km/h on the Antler hill and Blindman hill crests, respectively. There were not enough samples for the other extra length truck trains; what data there was suggested that the Rocky Mountain Doubles travelled at 10-15 km/h below the legal length truck combinations, and the Triples at speeds slightly lower than the Turnpikes. The Triples would tend to be driven slower because of the rough ride the trailers would experience at higher speeds.

Aside from the vertical alignment factors, truck mass and power can also retard or aid the hill-climbing performance. Overlength trucks, on the average, will tend to weigh more than the general truck population because they can carry more cargo, but more so because they are rarely run empty[15]. To offset this, the carriers may use the more powerful tractors. A Michigan study theorized that 261 KW (350 hp) is the minimum engine power required to pull trucks 52,300 kg heavy in order to maintain a certain crawl speed on grades. The mass-power ratio attained is about 200 kg/kW (330 lbs/hp), which is an upgraded requirement since the days of the Triple test with a 243kg/kW (400 lbs/hp) ratio tractor engine.[1]

TABLE 4. TRUCK ACCELERATION DATA AT LEDUC VEHICLE INSPECTION STATION

TRUCK TYPE (sample size)	MASS	SPEEDS AT: (distance back from the taper end) 700 m	600 m	500 m	400 m	300 m	200 m	100 m	(taper end) 0 m	AVERAGE ACCELERATION (km/h/s)
Tractor Trailer (32)	under 30,000 kg	65 km/h	69	73	76	78	81	83	85	.60
Tractor Trailer (14)	over 30,000 kg	60	63	66	67	72	74	77	79	.50
Regular Double (4)	under 30,000 kg	66	70	73	75	78	80	83	85	.60
Regular Double (25)	over 30,000 kg	54	58	60	62	66	68	70	72	.45
Rocky Mountain Double (3)	over 30,000 kg	57	60	62	66	68	70	73	74	.45
Triple (2)	under 30,000 kg	62	65	72	71	75	78	80	82	.60

Acceleration

As pointed out earlier, extra length trucks will normally outweigh other legal length trucks, and for this reason, their acceleration capability will be comparatively lower. In a 1981 FHWA (Federal Highway Administration) study showed that a .7 km/h/s average acceleration rate was obtained for truck trailers, while regular doubles had a rate of only .4 km/h/s/[14].

Analysis of the radar studies at the Leduc scale indicated two performance groupings: trucks under 30,000 kg and trucks over 30,000 kg (Table 4). The former had an acceleration of .60 km/h/s, the latter .45 km/h/s; both groups operating at 60-80 km/h. From on-board observations, the Turnpikes exhibited a similar range of .45 - .60 km/h/s.

The impact of slower acceleration would become more noticeable on two-lane roads because trucks would take longer to reach mainstream traffic speed, thereby delaying the following vehicles longer.

Passing

On a divided highway such as Highway No. 2, passing is generally not considered an essential operational concern; however, it is a critical element in an undivided highway setting. Since the trial test ran exclusively on a divided rural highway, no passing data on undivided highway was available for the overlength truck combinations.

Passing time required for a car travelling 15 km/h faster to pass a 23 m long truck vehicle doing 100 km/h on a two-lane highway was measured to be 15 seconds. If the same car attempts to pass a longer truck train at the same rate, the extra time and distance needed would be proportional to the extra length of the truck combination. The increase would be 10% more to pass a Rocky Mountain Double, 13% for a Triple, and 20% for the Turnpike. In absolute numbers, the car driver would require 96 m more roadway to accomplish a pass on a Turnpike Double. Other trucks would need two to three times longer passing room in order to pass the overlength truck trains because of the poorer acceleration performance as compared to a car.

The speed of the truck being passed has a great deal of influence on the passing time - from observations, passing times were trimmed by as much as 5-6 seconds when the truck speed dropped from 100 to 90 km/h. The relationship is not linear because of the difference in the acceleration characteristics at higher speeds. The implication is that by requiring the overlength trucks to operate at a lower speed, it could offset any increase in passing time due to the extra length. The disadvantage would be an increase in vehicles needing to pass the trucks.

Trucks travelling at lower speeds on a two-lane highways may degrade the level of service by increasing delay to following vehicles. If shoulders are not wide enough (2-3 m) for trucks to pull over as a courtesy for the vehicles behind, the delay would be even higher. Alberta's experience with passing as related to level of service indicated that roads with 2500-5000 AADT may require passing lanes. The presence of longer truck combinations can add to the platooning and the need for more passing lanes.

In Nevada, where the overlength trucks can legally run on two-lane highways, the Highway Department reported in 1968 that passing times involving all truck configurations were nearly identical. The theory was that the car drivers accelerated more to compensate for the extra distance. But an Austrailian research indicated otherwise, that passing times increased with increasing truck lengths[4]. Saskatchewan is currently engaged in a passing study on the Rocky Mountain configuration operating on a low-volume two-lane highway during nighttime conditions.

Aerodynamic Effects

Aerodynamic disturbance and the splash and spray created by trucks are possible hazards to passing vehicles, especially for oncoming vehicles in a two-lane situation. The demonstration test revealed no greater air turbulance surrounding the overlength truck combinations, and with anti-sail mud flaps, the water spray was not disruptive. The only undesirable effect was that the exposure to the aforementioned elements lasted longer. It is predicted that the long combination trucks would not cause any more snow swirl than ordinary trucks.

Emergency Braking

Panic stopping distances vary from one truck to another. The reasons are many, among which are the tire type and pressure, axle loading, road traction, and the condition of the brakes. The trailer length can also have an effect due to load transfer from the rear to the front in a braking situation.

Alberta's previous Triple test demonstrated the Triple to have superior stopping distance to the tractor trailer, but required slightly more distance than the regular double[1]. Ontario's test showed the Triple to perform a little better than the Turnpike[8]. In another comparison test, the California Department of Transportation could not reveal a consistent advantage for one overlength configuration over another[13]; suffice it to conclude that with proper maintenance of the brake system, a long combination vehicle's braking capability can be equal to any other truck.

The other important aspect to emergency braking is the integrity of the train alignment. Previous Alberta tests showed the Triple to keep intact in its straight position during deceleration; however, the recent California test had trailers sliding sideways as a result of wheel lock-up. As was the case with the Ontario test, improper hook-up and misalignment of the braking system probably caused the instability. Vehicles with more articulation points and axles are more prone to this unstable behaviour. But to emphasize an earlier point, there is no reason why overlength truck combinations would be more susceptible to brake-induced trailer swing or jackknife, as long as the equipment is adequately inspected and maintained.

Stability

Under normal highway driving conditions, all articulated vehicles have some sort of low amplitude swaying motion at the articulation points - a result of the continuous small steer corrections necessary to keep the vehicle in a straight line and the vehicle response to road imperfections[8]. Because of the number of articulations and the shortness of the trailers, the Triple is known for its undulation. In contrast, the Turnpike has a very stable form, with the Rocky Mountain Double exhibiting a similar form.

Rain and cross-wind were not perceived to have an adverse impact on this sway. Test with empty trailers did not produce a noticeable increase in this oscillation. Using the "A" dolly, however, did appear to amplify the sway somewhat, especially during a normal lane change. In the end, it was still the driver that made all the difference in how well the vehicle was handled, regardless of the truck configuration type.

It is important to bear in mind that small swaying motion is not indicative of impending loss-of-control, though it can have a disconcerting effect on drivers in the adjacent lane. In the two-lane operation, opposing car drivers' tendency to shy away from large trucks is expected to be more pronounced if the truck sway becomes obvious.

What may develop into an instability situation lies in the dynamic response of the vehicle train to rapid and sudden steering. Emergency evasive action is a rare occurrence, and the link to real-life collisions is not known. As in panic braking, it still warrants certain attention.

Testing grounds in Ontario and in Michigan have been used to test various configurations to their limits of stability[5,11]. Rearward loading was determined to be more detrimental to the train's stability than the trailer length; one logical conclusion is that a reverse Rocky configuration can be just as stable as the normal setup, provided the lead trailer is heavier than the back trailer.

Another finding of the research was the superiority of the "B" type dolly over the conventional "A" type in emergency situations[5,7]. The double drawbars of the "B" dolly made it possible to resist lateral forces, a vital function that would prevent dolly jackknife and not present in the "A" dolly. Coupled with the "B" dolly's ability to provide an experienced driver with a "feel" for impending loss-of-control, the driver was given more time to take corrective measures.

Offtracking

In any vehicle where the rear axle cannot turn, the path that the rear tires follow during a turning manoeuvre will deviate or offtrack from the path of the steering tires. There are two types - high speed offtracking and low speed offtracking.

At typical highway speeds on a curve, the rear trailer tires may "outboard" or track to the outside of the tractor tires; the magnitude is usually small. The highway between Calgary and Edmonton has a minimum radius of around 700 m, and as confirmed by actual recordings, the outboard movement was negligible. Where it may become a problem would be on narrow two-lane roadway with low standard curvature.

Inboard low speed offtracking is the other type of deviation that is more common and represents a greater hazard. In low speed turns, tire-to-road interaction results in a response whereby the rear tires would be pulled inward of the steering path. The phenomenon is a function of the radius of the turn and the wheelbase length of the vehicle. The longer the wheelbase, or the tighter the radius, the greater the deviation.

Several urban intersection designs were simulated on an off-road site for the Alberta demonstration. All the overlength combinations were tested, including the reverse setup of a Rocky Mountain Double. The "A" dolly and the "B" dolly were compared in the Turnpike and the Rocky Mountain Double configurations. Complete details will be written up in a technical report later on.

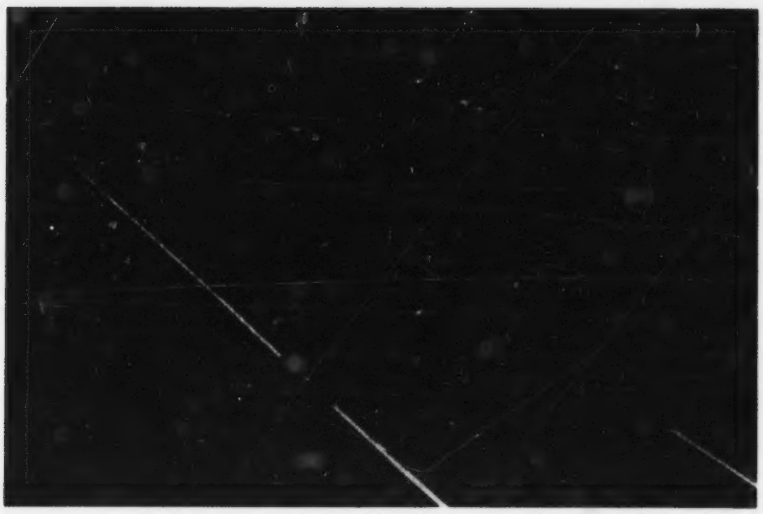
By far, the least manoeuvrable train was the Turnpike, then the Rocky Mountain Double, with the Triple being the most manoeuvrable. If operated strictly under all the legal traffic rules, the Turnpike required a minimum of 30 m radius for turns, the Rocky Mountain Double, 25 m radius, the Triple, 20 m radius. Thirty metres radius is rarely encountered at normal urban intersections. In practice, drivers often try to make use of whatever room is available - shoulders, adjacent unoccupied lanes - to manoeuvre the truck. So, it is more realistic to suggest a 25 m minimum radius for the Turnpike (Diagram 4), 20 m for the Rocky Mountain Double (Diagram 7), and 18 m for the Triple (Diagram 8).

Potential obstacles for the Turnpike would be a one-way arterial intersecting another one-way street, tight diamond left turns, and right turns coming out of local or collector roads. At these locations, the long combination truck would need to encroach significantly onto the adjacent or opposing lanes in order to negotiate the turn. Another situation that can represent a problem is interchange ramps; the ramp tested (Diagram 6 - 30 m radius, 6 m wide, 20^0 skew) could have precipitated a rollover because the rear tires rode over the curb edge. The Rocky Mountain Double

OFFTRACKING TEST

Test Site

Marking System



Measurements

PLATE 2

is not nearly as restricted, though tight diamond left turns and low geometric right turns are still a problem. The Triple would have relatively little difficulty on the majority of city designated truck routes.

Actual operation in the field confirmed the test results, but some surprising observations were recorded. In several incidents, car drivers in the adjacent left turn lane appeared to realize that the long truck vehicle would encroach onto their lane, and stopped to wait for the truck to complete the left turn first. Yet in another event, a truck trailer attempted to turn left from the inside lane at the same time the Turnpike was making a left turn from the outside lane; the driver in the Turnpike had to stop the tractor trailer.

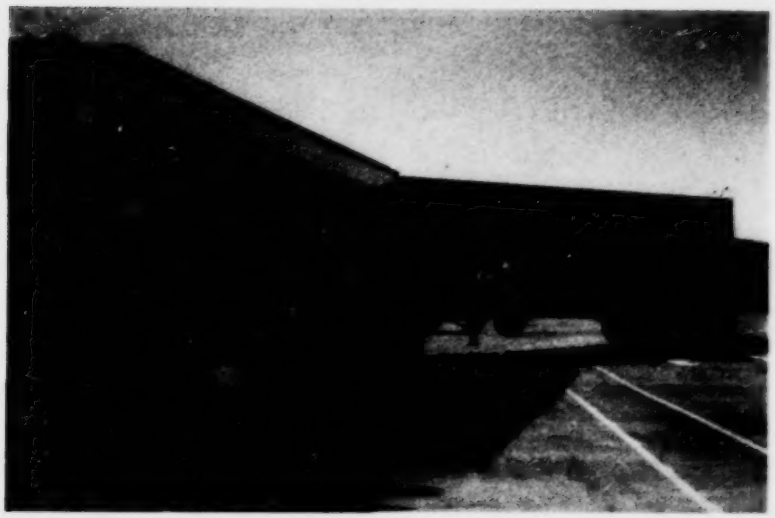
In the comparison between the "A" dolly and the "B" dolly, indistinguishable paths were produced. Negligible to less than .5 m of improvement was measured from the "B" dolly, corresponding to an earlier Ontario experiment[5]. Unless the intersection geometrics are so confined that .5 m will make the difference, the "B" dolly will not enhance an articulated truck's manoeuvrability a great deal.

The reverse Rocky Mountain Double proved to be as manoeuvrable as the regular configuration. Only that the initial and the recovery portions of the offtrack became lengthened; the longer trailer at the back was the reason.

Translating all these findings into rural oriented environment means that the Turnpike will not be able to negotiate many of Alberta's flared intersections without interfering with the approach road and the mainstream traffic. At interchanges, the limiting exit and entry radius was observed to be 30 m on a 9 m wide surface (SR 596 interchange, west of Red Deer was the test site). Some of the older interchanges may not be able to accommodate the Turnpike.

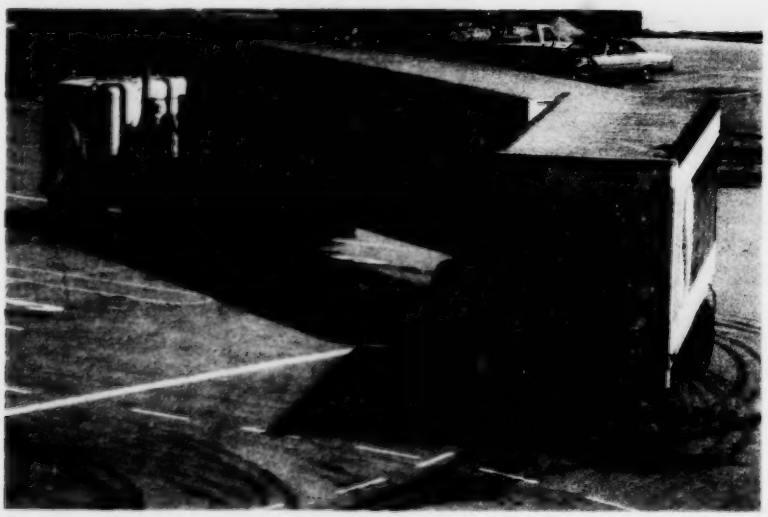
With some intrusions, the Rocky Mountain Double and the Triple would be able to manoeuvre around typical two-lane and four-lane intersections with 3 m wide shoulders. Skew angled intersections could handicap the truck's ability. The other hazard all overlength truck combinations present at divided at-grade intersections is the lack of wide enough median openings for refuge. The trailers would protrude and block portions of the travel lane if the trucks entering from the cross road have to stop in the median of the highway.

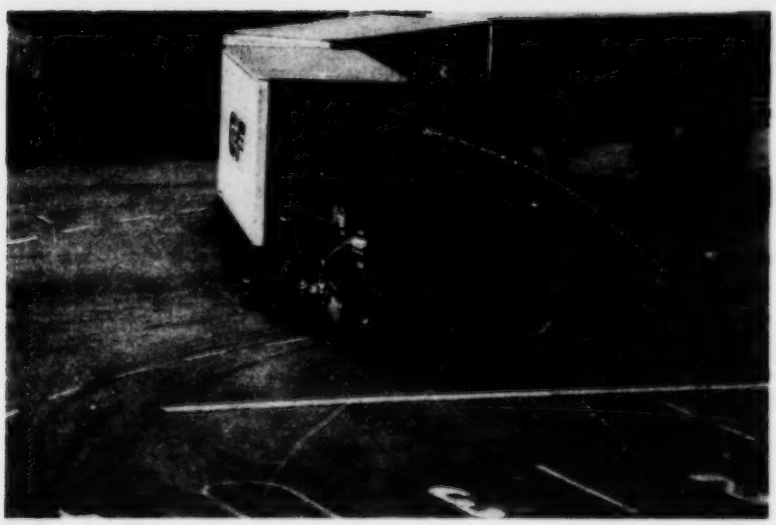
TRUCK COMBINATIONS TESTED FOR OFFTRACKING



Turnpike Double

Rocky Mountain Double





Triple

PLATE 3

TURNPIKE DOUBLE MANOEUVRES AT INTERSECTIONS

urn at an intersection of one-way streets.

Right turn on an urban interchange ramp.

rom a rural interchange loop.

PLATE 4

DIAGRAM 4

Alberta TRANSPORTATION

TURN MANOEUVRE : LEFT 4 – 5

TEST DATE : MAY 15/85

SCALE : 1 : 500

LEGEND

- TRACTOR STEERING AXLE
- DOLLY AXLE
- REARMOST AXLE
- INDICATES DIRECTION OF TRAVEL
- TURNING GUIDE LINES

TURNPIKE DOUBLE
"A" dolly

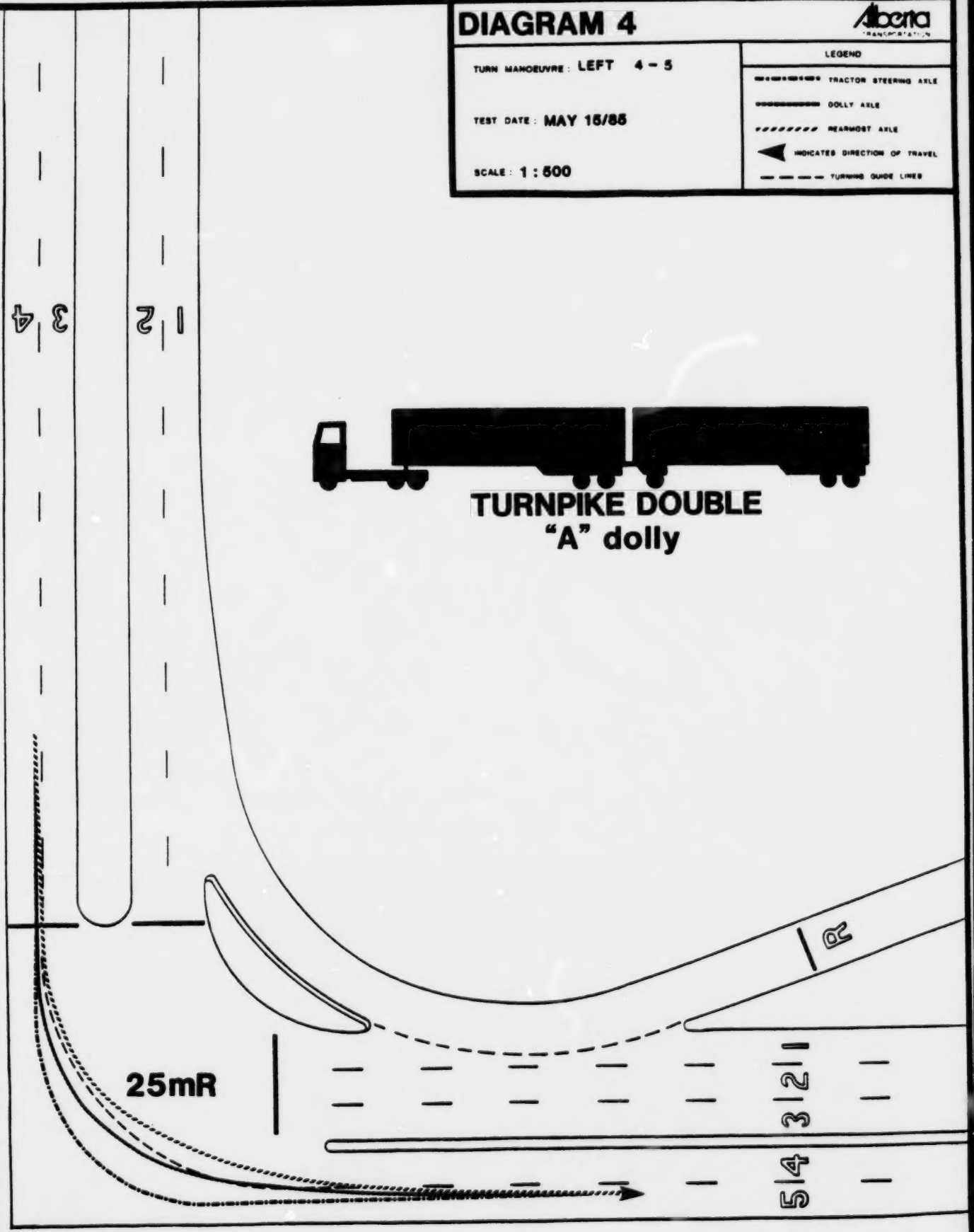


DIAGRAM 5

Alberta TRANSPORTATION

TURN MANOEUVRE : RIGHT 1 – 1
'unrestricted'

TEST DATE : MAY 15/85

SCALE : 1 : 500

LEGEND

- TRACTOR STEERING AXLE
- DOLLY AXLE
- REARMOST AXLE
- INDICATES DIRECTION OF TRAVEL
- TURNING GUIDE LINES

TURNPIKE DOUBLE
"A" dolly

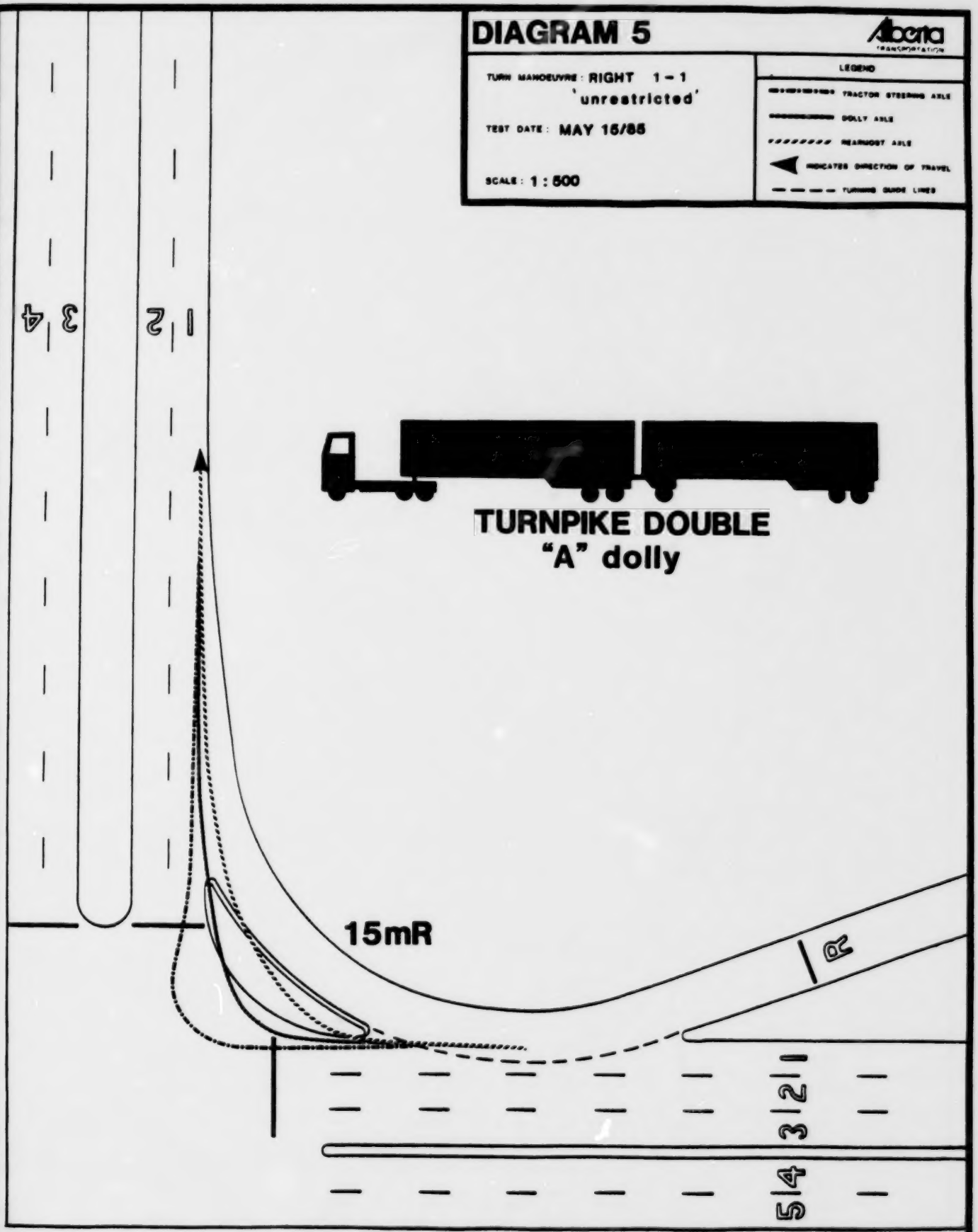


DIAGRAM 6

Alberta TRANSPORTATION

TURN MANOEUVRE : RIGHT R – R

TEST DATE : MAY 15/85

SCALE : 1 : 500

LEGEND

- TRACTOR STEERING AXLE
- DOLLY AXLE
- REARMOST AXLE
- INDICATES DIRECTION OF TRAVEL
- TURNING GUIDE LINES

TURNPIKE DOUBLE
"A" dolly

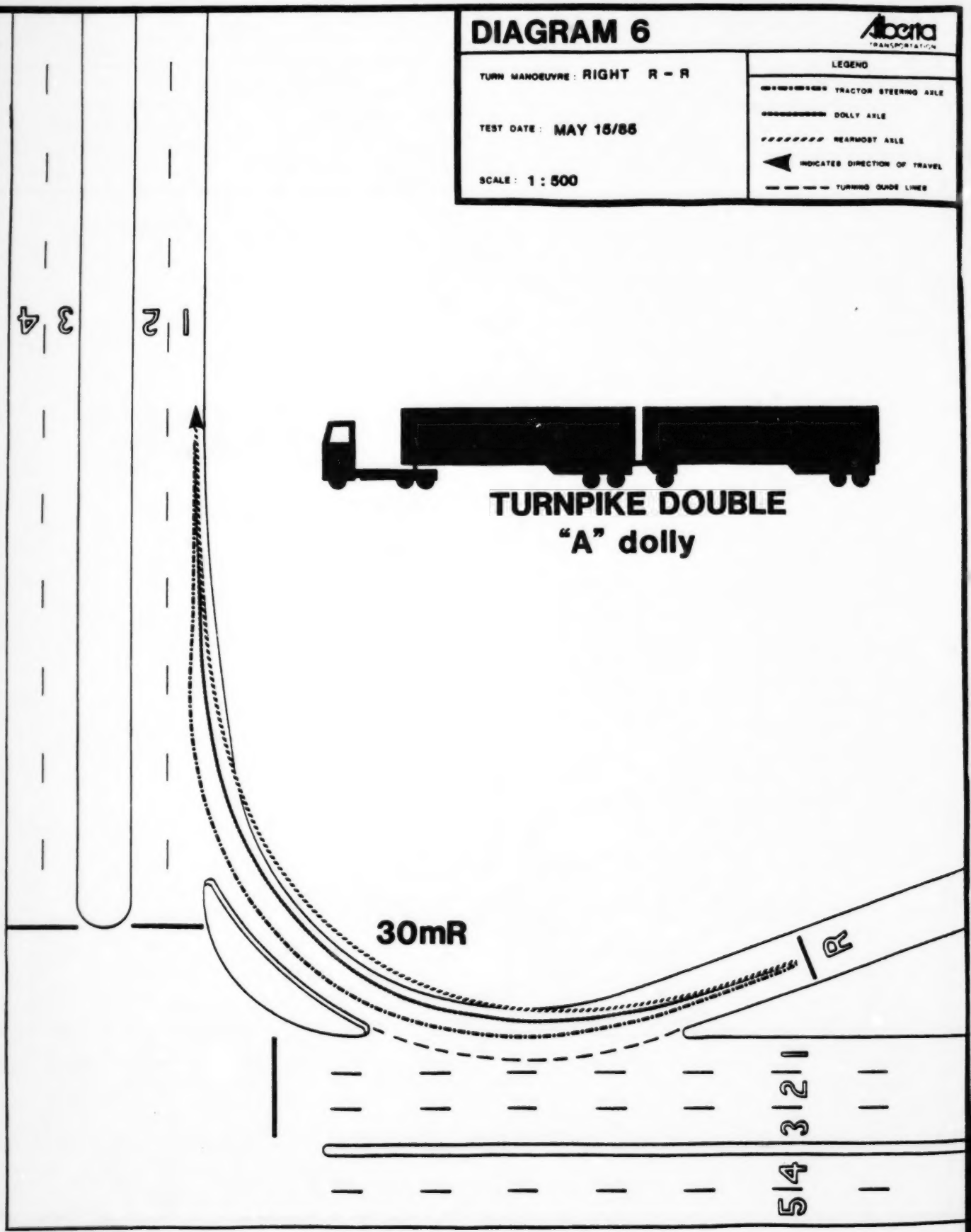


DIAGRAM 7

Alberta TRANSPORTATION

TURN MANOEUVRE: LEFT 4 – 2

TEST DATE: MAY 16/86

SCALE: 1 : 500

LEGEND

- TRACTOR STEERING AXLE
- DOLLY AXLE
- REARMOST AXLE
- INDICATES DIRECTION OF TRAVEL
- TURNING GUIDE LINES

ROCKY MOUNTAIN DOUBLE
"A" dolly

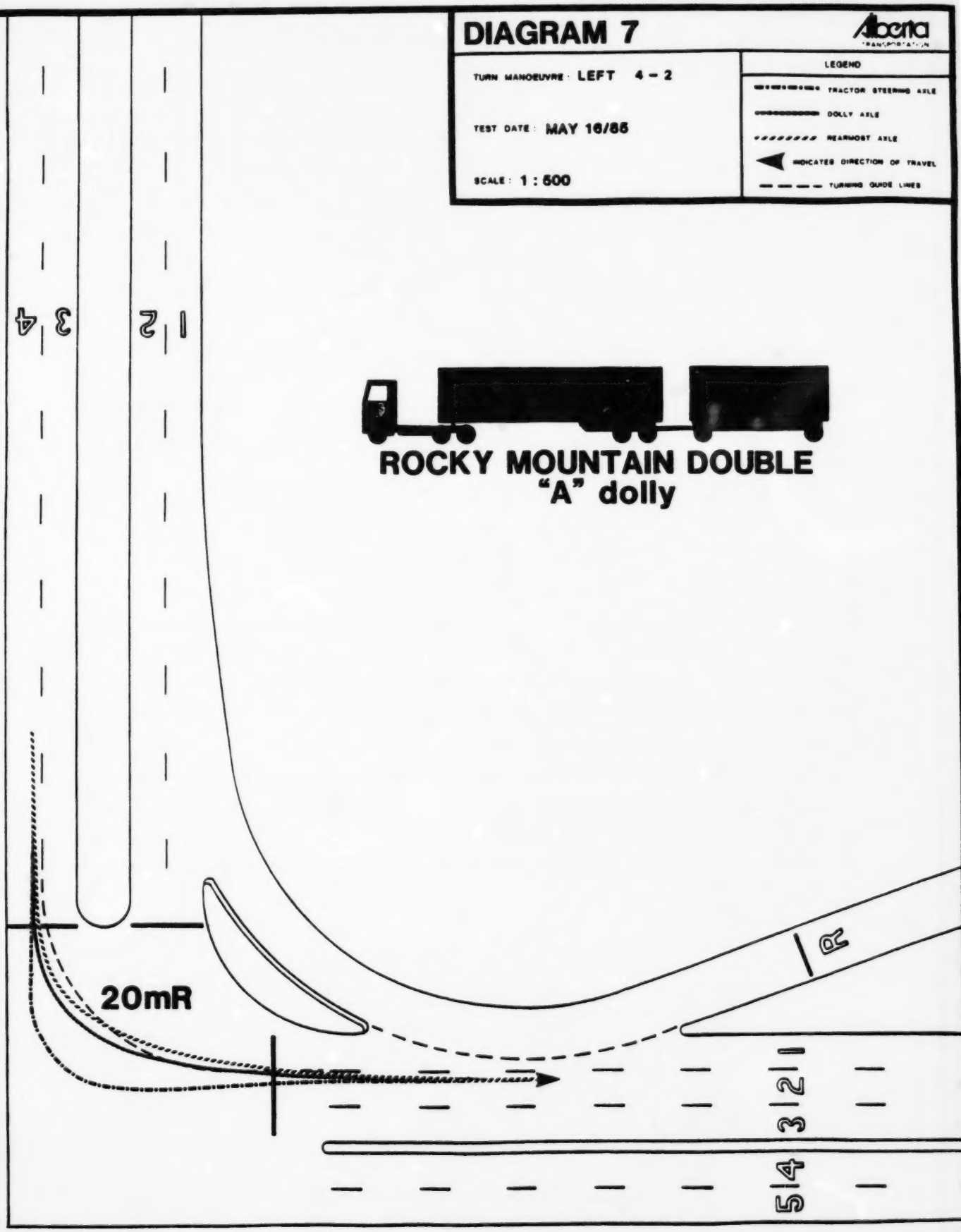


DIAGRAM 8

Alberta TRANSPORTATION

TURN MANOEUVRE : LEFT 1 - 5

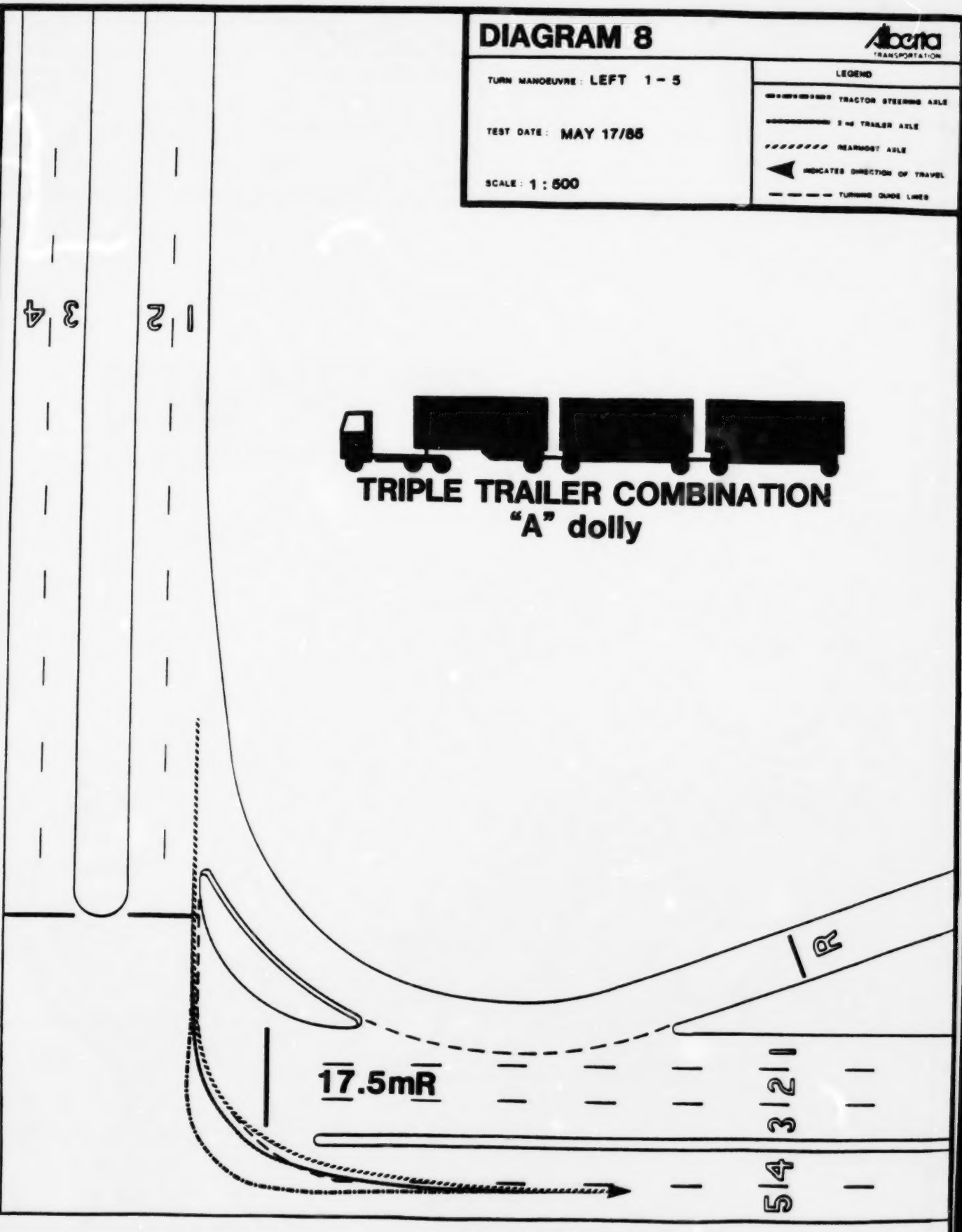
TEST DATE : MAY 17/85

SCALE : 1 : 500

LEGEND

- TRACTOR STEERING AXLE
- 2 nd TRAILER AXLE
- REARMOST AXLE
- INDICATES DIRECTION OF TRAVEL
- TURNING GUIDE LINES

TRIPLE TRAILER COMBINATION
"A" dolly



General Observations

Aside from the manoeuvring, one other problem that overlength vehicles can create at intersections concerns signalization. Because of the extra length, the trucks would take longer to pass through the intersections. From start of green, the Turnpike required 14-16 seconds to cross a divided intersection, or equivalent to about 5-7 car lengths. A significant number of these trucks arriving during peak hours could deteriorate the intersection capacity.

Another signal-related issue is the clearance interval that separates the conflicting greens. If the truck enters the intersection on an amber, the trailer(s) would occupy the intersection for a portion of the red. The potential safety implication means it may become necessary to extend the clearance interval to accommodate the overlength truck combinations, a further detriment to the intersection capacity.

A nighttime observation of the Turnpike operation revealed no out-of-ordinary incidents; it was no different from the daytime movement.

The most impressive aspect throughout the test was the professionalism of the drivers involved. The fact they knew they were being watched obviously motivated them as well. When they were not aware of being monitored, their behaviour reverted to more natural habits. As was the case with the other drivers, some minor infractions were recorded, like failure to signal, straddling two lanes to start and to complete the turn. The incidents were minor because the truck drivers appeared to be cognizant of the surrounding traffic. The point is that the drivers cannot be monitored at all times, the habits and attitudes of the drivers will determine how well the overlength truck combinations are perceived and accepted by the public.

TRAFFIC COLLISIONS

No actual traffic crashes were recorded during the test period. Collisions statistics have not been maintained for the long truck combinations over the years, so the only source comes from the fleet carriers that keep such files. Canadian Freightways' safety experience with Triples in Alberta has been exceptional, but the company's record is not a representative yardstick for all other overlength vehicle users, and certainly a distance above the remaining truck population.

The validity of using large companies' safety record as a gauge of the long combination trucking industry's track record is questionable; they operate under stringent regulations, have better drivers and equipment, and are usually restricted to certain routes[15]. It is likely that the good collision experience the overlength trucks are enjoying will continue for as long as the operating circumstances remain intact.

Literature on this topic is quite ambiguous, ranging from heavy trucks being over-represented in crashes to trucks being safer than automobiles. What is generally true is that trucks do cause greater severity; comparisons with several provinces showed heavy trucks to be involved in 2-5% total collisions but in 13-17% injury and fatal crashes. From the DelCan study on car-truck size disparity[4], it can be inferred that overlength truck vehicles would not create any higher severity in collisions than the legal length trucks.

A couple of related issued surfaced in the discussion of safety - trucks running empty trailers were involved in crashes more frequently than the loaded combinations[15]; the "A" trains appeared more often than the "B" trains in rollover collisions[9]. The first item may be of concern with the Turnpikes, where deadhauling empty trailers can be common. The second observation is interpreted as correlation to the laboratory tests on the "A" dolly stability problem; unfortunately, extensive research in this area is not available to fully substantiate this.

CURRENT PERMIT PRACTICES

All jurisdictions issue special permits for the operation of overlength vehicles. The message that the permits carry is far more convincing than the normal licensing system - it is a privilege to operate the overlength vehicles, not a right. The revocation power of the permit helps to deter outright violations of the rules. Inspection of vehicle units at each application and renewal is required, making the company more equipment-conscious. Quebec is more vigorous in this respect, requiring an inspection every three months.

The notion of being privileged is carried through onto the driver requirements. Saskatchewan and Quebec permits stipulate the drivers to have a certain amount of truck driving experience; in addition, Saskatchewan has an air brake endorsement for the drivers. Some states can be more stringent, requiring minimum driver age, company supervision, a clean driving record and a special operator licence. From the inception of Triples to the recent testing of the Turnpikes in Alberta, the big companies have, on their own initiative, employed only the most "professional" drivers on the overlength truck combinations.

Designating highway routes for overlength vehicle movements is a very integral aspect behind the system of permits. The current accepted philosophy in Canada is to permit these vehicles only on divided highways, on a route-by-route review basis. Saskatchewan is testing Rocky Mountain Double operation on a low volume two-lane road during night conditions only. While some neighboring western states have permitted cross-border movements, they also have divided interstate facilities which is not the case of the prairie provinces. Furthermore, the many two-lane roads allowed in those states is not a representative situation for Alberta.

Absolute access control was a governing condition in the operation of Turnpike Doubles on the heavily used turnpike toll roads, entries and exits can only be made at toll booths. Staging areas are constructed along the route so that the combinations can be broken down into single units. Where the Turnpike is allowed to travel as a whole unit outside the system, the route is usually restricted to grade-separated interchanges and high geometric designed roads (see Table 3).

In Alberta, it is up to the local municipalities to approve access within their jurisdictions. Routes may be reviewed for manoeuvring and other problems before approval is given. This is generally the case for other provinces and some states. But few or no guidelines are available to these authorities, so what is being permitted in Carson City of Nevada may not be comparable to Edmonton or Calgary because of the difference in traffic characteristics and road geometry - Carson City has about 35,000 population versus over half-a-million in each of the two Alberta cities.

Other restrictions peculiar to each province range from operational items, like time and speed, to equipment requirements. The reasons for Alberta's and Manitoba's weekend restrictions is to separate the truck from the heavier weekend traffic. Quebec does not allow winter operation; in addition, overlength truck combinations are required in Quebec to be equipped with tachographs for speed monitoring. Through tests done by WHI, anti-sail mud flaps have become de facto for the prairie provinces. A major requirement breakthrough came from Saskatchewan, where after comparative testing with the "A" dolly, the "B" dolly converter and the "B" train were implicitly made a standard in permits for all overlength truck combinations.

Sequencing of unequal length trailers for the Rocky Mountain configuration is an issue in Alberta, the permit states the front trailer must be the longest. Many jurisdictions stipulate that the heavier vehicle be in the front, regardless of the length difference; some states go on and specify the weight difference in pounds or by percentage difference.

CONCLUSION

Overlength truck trains, when compared to the other trucking population, will tend to be operated at lower speeds, and have poorer acceleration performance on both level roads and on grades. For the amount of traffic on Highway No. 2, the disruption to the traffic flow will be minimal if the Turnpike is added to the stream. Where the problem may manifest itself is on moderate to high volume two-lane roads. Delays to the other traffic may generally increase, to what degree will depend on the traffic mix. If the overlength truck units are operated at high speeds, the impact of increased passing times may fuel the need for more passing lanes. On the other hand, the truck drivers' courtesy of moving over to the shoulder (assuming adequate shoulder width) would lessen the impact.

Manoeuvring is a major concern with the Turnpike, and to a lesser extent, with the Rocky Mountain Double. Not all the interchanges or at-grade intersections can accommodate Turnpike Double movements safely. The risk of collisions with other vehicles and highway furniture increases at low geometric intersections. Two-lane operation is envisaged to adversely impact the rural intersections and roads in the smaller communities. The Rocky Mountain Double, being shorter than the Turnpike Double, would be able to negotiate the higher standard intersections that have a 3 m shoulder.

While the Triple is the most manoeuvrable vehicle, this configuration has the least desirable stability characteristics, as compared to the double combinations. For this reason, two-lane operation of Triples involves a greater safety concern.

The "A" dolly has been shown to be susceptible to dolly jackknife, and to accentuate directional control loss in the rear trailer. Questions raised from an in-depth collision study infer that the "A" trains may be involved in more collisions than the "B" type articulated trucks.

A true safety picture cannot be established. What is known accurately is that the longer truck combinations are less prone to collisions than the average trucks. But the good record is not attributable to the actual configurations as much as to the strict controls placed by the carriers and by the road authorities. As confirmed time after time throughout the Turnpike study, the use of experienced and skillful drivers compensated for some of the weaknesses of the truck's capability.

The importance of the permit conditions cannot be over-emphasized. As long as the operators are conscious of the need to employ well-trained drivers, to inspect and maintain the equipment, and to participate in the safety of their drivers and the public, the clean image these trucks foster will continue. If the rules are relaxed, such as allowing the trucks to operate everywhere, operational and safety problems mentioned earlier will become obvious.

The fact that some western states permit the trucks to run relatively unhindered within and across the border is not a reflection of the situation in the prairie provinces. None of the three provinces has highly developed divided freeways, connecting the centers in each province. In Alberta, two-lane highways generally have higher traffic flows, and more cross-road traffic. The road environment and the traffic characteristics are sufficiently different from those in the sparsely-populated western states so that a direct comparison is not valid.

RECOMMENDATIONS

1. Turnpike Doubles should be permitted to operate where existing overlength truck combinations are allowed - on designated divided rural highways. Full access control must be exercised; in city areas, the local authority should review the route to ensure compatibility with the road geometries.

   As a standard, 15.2m (50 ft) trailers should be the maximum trailer length allowed with a further stipulation of 35 m overall length.

   To handle the increased number of overlength trucks, the existing safety inspection program should be expanded.

2. The "B" dolly or the "B" train configuration should be made a part of the permit requirements of the Turnpike Double. Consideration should be given to phasing in this requirement for all overlength truck combinations in the future.

   The special conditions that come with the "B" converter dolly should be adhered to - the centering mechanism should be locked when travelling on slippery road surface; hitch eyes should be able to withstand heavy vertical forces[7].

3. Reverse versions of the Rocky Mountain Double should be allowed to operate, with the condition that the front trailer should be heavier than the back trailer.

4. The load differential rule should apply to all other overlength truck combinations, with a further stipulation that the back trailer of the Triple should be the lightest.

5. Operations of overlength truck trains on two-lane undivided highways should only be considered for double-trailer combinations upto 29 m overall length, and only on designated highway routes that meet the high standard requirements for passing and manoeuvring.

REFERENCE

(1) "Report on the Testing of Triple Trailer Combinations in Alberta," Alberta Department of Highways and Transportation, Edmonton, Alberta, April, 1970.

(2) "Seven-Axle Truck Project," Alberta Transportation, Transportation Safety Branch, April, 1983.

(3) "Evaluation of the Offtracking Performance of Standard and Overlength Vehicles," Transportation Agency of Saskatchewan, November, 1982.

(4) "Report of the Ontario Commission on Truck Safety," The Ontario Ministry of Transportation and Communications, April, 1983.

(5) J.R. Billing et al., "Test of a B-train Converter Dolly," The Ontario Ministry of Transportation and Communications, May, 1983.

(6) J.H. Woodrooffe et al., "A Generalized Mathematical Solution for Transient Offtracking of Single Vehicles and Truck Combinations," National Research Council of Canada, 1983.

(7) J.H. Woodrooffe et al., "Characteristics of Truck Combinations with the Double Drawbar Dolly," Roads and Transportation Association of Canada, Ottawa, 1983.

(8) "Test and Demonstration of Double and Triple Trailer Combinations," The Ontario Ministry of Transportation and Communications, August, 1982.

(9) "Commercial Vehicle Accident Survey - An On-the-Scene Study," The Ontario Ministry of Transportation and Communications, January, 1982.

(10) "Joint RTAC-CCMTA Committee Report on Vehicle Weights and Dimensions," Conference of Ministers Responsible for Transportation and Highway Safety, Fredericton, N.B., April, 1981.

(11) R.D. Ervin et al., "The Influence of Size and Weight Variables on the Roll and Stability of Heavy Duty Trucks," Final Report, UMTRI-83-10, University of Michigan, March, 1983.

(12) R.D. Ervin et al., "An Overview of the Dynamic Performance Properties of Long Truck Combinations," UMTRI-84-26, University of Michigan, July, 1984.

(13) "Longer Combination Vehicles Operational Test," California Department of Transportation, March, 1984.

(14) G.R. Vallette et al., "The Effect of Truck Size and Weight on Accident Experience and Traffic Operations," Final Report, FHWA/RD-80/135, 1979.

(15) M. Freitas, "A Review of Accident Research Involving Truck Size and Weight," Public Roads, Vol.46, No.2, September, 1982.

(16) M. Freitas, "Safety of Twin-Trailer Operations," Public roads, Vol.48, No.4, March 1985.

(17) "Review of Safety and Economic Aspects of Increased Vehicle Sizes and Weights," Western Highway Institute, September, 1969.

(18) "Traction Characteristics of Trucks and Truck Combinations - 1969 Winter Traction Tests," Research Committee Report No. 1, Supplement No. 1, Western Highway Institute, 1970.

(19) "Offtracking Characteristics of Trucks and Truck Combinations," Research Committee Report No. 3, Western Highway Institute, February, 1970.

(20) "Motor Vehicle Size and Weight Standards - Western Regional Objectives, Executive Summary," Western Highway Institute for the TRED, July, 1980.

(21) Materials, video tapes, and discussions from various government agencies: British Columbia, Saskatchewan, Manitoba, Ontario, Quebec, California, Idaho, Oregon, Nevada.

Alberta
TRANSPORTATION
Motor Transport Board

PERMIT NUMBER RE 33123

NON-FEE PERMIT

Pursuant to authority vested in the Motor Transport Board under the Provisions of the Motor Transport Act, permission is hereby granted to:

- [ ] Transport commodities that exceed the dimensions allowed under the provisions of the Motor Transport Act.
- [ ] Transport commodities extra-provincially in lieu of an operating authority certificate.
- [ ] Transport commodities intra-provincially in lieu of an operating authority certificate.
- [ ] Transport commodities in order to adjust the load.
- [X] Other (specify) to operate double trailer combination known as "Turnpike Doubles" for testing purposes.

Carrier	Commodity being transported
MacDonalds Consolidated & Safeways Ltd.	Various
Address of Carrier	**Owner of Commodity**
11523-160 St., Edmonton, Alberta	As required
Licence number	**If non-resident, indicate home jurisdiction**
As required	

From	Via		
Edmonton - Calgary (Access to Red Deer via 67 Street)	Calgary - Edmonton	Highway #2 as required	
Dimensions if applicable	**Width**	**Length**	**Height**
	---------- m	23 m	---------- m

CONDITIONS

STANDARD CONDITIONS

1. This permit is not valid if the dimensions of the vehicle and load exceed the usable or posted dimensions of any bridge, power lines, wires or structures.
2. This permit is not valid for the transportation of vehicles and loads in excess of 3.85 m wide,
   (i) from 3:00 p.m. until midnight on the day preceeding a weekend or statutory weekend, or
   (ii) on Sundays or statutory holidays.
3. This permit is not valid for loading or unloading at points other than those points designated.
4. This permit is not valid for the transport of commodities or equipment that exceed the dimensions allowed under the provisions of the Motor Transport Act, unless the carrier named above is in possession of a minimum of ~~$500,000.00~~ $1,000,000.00 Public Liability and Property Damage insurance coverage, that is valid in Alberta.
5. Conditions on the reverse side hereof form and are part of this permit.

VARIABLE CONDITIONS

- [ ] Vehicle and load must report to vehicle inspection station after adjustment prior to continuing to original destination.
- [X] Other conditions, specify Maximum distance from 5th wheel pin on tractor or centre of drive axles not to exceed 30 metres. The holder of this permit agrees to abide by the same conditions which were agreed to for the operation of "Triple Trailer and Rocky Mountain Double" combinations.

MUST COMPLY WITH ATTACHED CONDITIONS: MT3 26 TPD

Effective date	Date of Expiry	Phone in	Pick up
June 14, 1985	July 15, 1985	[X]	[ ]

Not Valid unless stamped by M.T.B.

Applicant

Signing Officer and location

J. R. Baynes
J. R. Baynes - Issuer
Equipment Consultant

Time

Contravention of the Motor Transport Act, its regulations, or the terms of this permit render this permit null and void.

TURNPIKE DOUBLE TRAILER COMBINATIONS

1. THAT the vehicles shall be attached in a safe and secure manner so as to assure that the vehicles may not become detached while in operation and that the trailers of the combination shall be joined together by means of no slack pintle hook(s) equipped with an air or hydraulic ram. The no slack ram to be incorporated in either the pintle hook or the pintle hook eye of the coupling apparatus.

2. THAT the permittee shall be responsible for obtaining permission from the cities of Calgary, Edmonton and Red Deer, where applicable, to operate the trailer combination into and out of said cities in accordance with the routes assigned by the cities.

3. THAT the permittee employ, for this operation only, such drivers who have been fully trained and who are well skilled in operating trailer combinations and that such drivers shall be otherwise well experienced and of good driving record.

4. THAT the power unit be adequately geared and powered to be able to maintain speeds at which other trucks and truck trailer combinations usually travel.

5. THAT the system of brakes operate in an efficient manner and be so engineered and designed as to provide braking effort to axles as approved by Transport Safety Branch, Alberta Transportation.

6. THAT vehicles in a combination shall be so designed, constructed, and coupled together as to ensure that any such combination travelling on a level, smooth, paved surface will follow in the path of the towing vehicle without shifting, swerving, or swaying from side to side over 7.62 centimetres to each side of the path of the towing vehicle when it is moving in a straight line.

7. THAT the trailer combination be equipped with mud flaps or splash guards which must meet the following specifications:

   (a) They shall be anti-sail type, constructed of a material that will keep the flap in a rigid, perpendicular, downward position at all times.

   (b) They shall be a minimum width of 60.00 cm and shall be mounted behind the trailer wheels at a distance not exceeding 25.00 cm to the rear of the wheels and not more than 15.00 cm from the road surface.

   (c) They shall be mounted to the underside of the trailer body in a manner that will not allow road spray to pass over the top of the flap and the trailer body.

8. THAT, in addition to the lighting requirements prescribed by law for other vehicles or combinations, the trailers be equipped with lateral amber lights visible on each side to cross traffic and that such lights be suitably spaced at intervals approximately one-third of the total overall length of the trailer combination.

9. THAT no operation be engaged in over weekends (i.e. between the hours of 4:00 p.m. Friday to 12:01 a.m. the following Monday). In the event of a statutory, provincial or civic holiday occurring on a Monday, then the operation shall not commence until 12:01 a.m. on the following Tuesday.

10. THAT no operation shall be engaged in on any statutory holiday, nor after 4:00 p.m. on the day immediately preceding the statutory holiday.

11. THAT the permittee shall employ a safety supervisor whose duty will be to oversee and direct the safe operation of these trailer combinations including the proper functioning and design of all equipment that is entailed in such operation.

12. THAT the permittee will do all things necessary to operate in a safe and efficient manner, having due regard to weather conditions upon the highway and the traffic thereon, and refrain from operating when the highway is icy or heavily snow covered, or when the operation may otherwise pose a particular hazard to traffic.

13. THAT the lead trailer shall be the longest and heaviest trailer in the combination.

14. THAT the vehicles not cross the opposing traffic lanes of Highway #2 except at interchanges.

15. THAT no entrance to or exit from Highway #2 be made except at interchanges, rest area turnouts, or where acceleration or deceleration lanes are provided.

16. THAT the permittee will allow observors to travel in the units during the testing phase.